

## SYSTEMS INTEGRATION

### i. Design Requirements Relating to Power Line Perturbations

#### General Design Principle

RHIC will be designed to hold and preserve beam quality of a stored beam when perturbed by small power line dips (of the order of 5% or less). If a power line changes by more than this threshold amount, the beam will be dumped and the stored energy will be extracted from all superconducting magnets. In this case all systems will be recycled to their start-up values and be ready to reload beams in approximately 5 minutes assuming the power outage is less than 60 sec.

To accomplish these objectives, the following system considerations must be observed.

#### Magnet Electrical System

Many of the magnet system power supplies are SCR regulated units which imposes a bandwidth limit on the regulator. Therefore, their transient response is not equal to their d.c. response. Table 0-3 lists the expected bandwidth limited transient response to a 5% power line dip of long duration (regulator recovers before the end of the "dip"). The beam is expected to retain usable quality after experiencing these perturbations.

For power line dips greater than this 5% threshold value, the beam will be dumped and the energy extraction system will be triggered, removing the energy from all superconducting magnets. These magnets will not be allowed to decay on their natural time constant because the energy extraction system may not be able to remain armed for an indefinite time.

#### Cryogenic System

As a primary principle, all electronic and mechanical systems of the RHIC helium refrigerator have been designed to be inherently fail-safe so that under all conceivable conditions of failure, equipment will not suffer damage nor will operator safety be compromised.

Short term power dips, those which do not drop out the motor contactors of the helium compressors, will have little or no effect on the operation of the RHIC cryogenic refrigerator and allied systems. Most of the problems will be associated with the process control computer CPU which continually monitors the AC line and shuts itself down in an

**Table 0-3.** Estimated Regulator Response

	Response to a 5% Power Line Dip
Dipole	$1.4 \times 10^{-6}$
Quadrupole	$1.7 \times 10^{-5}$
Sextupole, ckt. #1	$2.0 \times 10^{-6}$
ckt. #2	$1.0 \times 10^{-6}$
Arc $a_1$ , ckt. #1	0.1%
ckt. #2	0.1%
Insertion $a_1$ , ckt. #1	0.1%
ckt. #2	0.1%
$a_0/b_0$	0.1%

orderly and safe manner upon detection of a missing half cycle or low voltage. The CPU has battery-backed memory with a 30 minute hold so minor glitches may put the computer through its power-down cycle, while the compressors continue to operate. In this case the I/O settings (both digital and analog) will remain in their last state until the computer comes back on-line automatically in about 30 seconds to 1 minute.

If the power is out long enough for the compressor contactors to drop out, the computer will power down as well. In this case, valves and all other outputs, both digital and analog, will go to predetermined fail-safe positions. When power returns, assuming battery-backup holds, the computer will restart and begin to update screen displays. Some control functions will start automatically, but the compressors would be started manually at present. Manual start of the compressors would take about 5 minutes. There is no reason why the compressors could not be started on a programmed basis in the future. In fact, we have plans to minimize energy usage by matching compressor capacity to refrigerator demand by turning off excess compression and modulating one compressor chain to minimize helium bypass flow.

With a cryogenic system there is a multiplier effect in down times. If the cooling system is down long enough to lose liquid in the coolers, the multiplier will be about ten or more, so a half hour of warm-up time of the magnets will cost five or more in reestablishing operating conditions.

**Vacuum System**

(To be specified)

**Beam Extraction System**

The beam extraction system must function in the absence of line power voltage. All pulsed kicker and septum magnets must have energy storage elements such as charged network or capacitor banks. All switch tube filaments must be driven from uninterruptible power sources. All low level electronics must also be driven from a battery sourced uninterruptible power supply, since capacitor energy storage is sometimes unreliable due to undetected leakage.

**rf System**

All power sources must have at least a 5% voltage reserve and a regulator capable of handling a 5% power line dip must be provided. The filaments voltage should be set on the high side so that they will withstand a 5% short lived dip or be supplied from a regulated source. All low level electronics must be designed and tested for a 10% power line dip.

**Beam Instrumentation**

All beam position monitors must be powered from regulated supplies and be able to function normally under the influence of power dips of at least 10%. Parts of the system that are required to provide beam dump triggers must be able to function satisfactorily for several seconds after all line power has been removed. A battery sourced uninterruptible power supply is recommended, since capacitor energy storage is sometimes unreliable due to undetected leakage.

**Controls**

All computer controls and their necessary satellites and interface units must be powered using uninterruptible power sources. All memories must be retained and no rebooting required.